

First results from a Swiss level I trauma centre participating in the UK Trauma Audit and Research Network (TARN): prospective cohort study

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Summary

QUESTIONS UNDER STUDY: Patient characteristics and risk factors for death of Swiss trauma patients in the Trauma Audit and Research Network (TARN).

METHODS: Descriptive analysis of trauma patients (≥ 16 years) admitted to a level I trauma centre in Switzerland (September 1, 2009 to August 31, 2010) and entered into TARN. Multivariable logistic regression analysis was used to identify predictors of 30-day mortality.

RESULTS: Of 458 patients 71% were male. The median age was 50.5 years (inter-quartile range [IQR] 32.2–67.7), median Injury Severity Score (ISS) was 14 (IQR 9–20) and median Glasgow Coma Score (GCS) was 15 (IQR 14–15). The ISS was >15 for 47%, and 14% had an ISS >25 . A total of 17 patients (3.7%) died within 30 days of trauma. All deaths were in patients with ISS >15 . Most injuries were due to falls <2 m (35%) or road traffic accidents (29%). Injuries to the head (39%) were followed by injuries to the lower limbs (33%), spine (28%) and chest (27%). The time of admission peaked between 12:00 and 22:00, with a second peak between 00:00 and 02:00. A total of 64% of patients were admitted directly to our trauma centre. The median time to CT was 30 min (IQR 18–54 min). Using multivariable regression analysis, the predictors of mortality were older age, higher ISS and lower GCS.

CONCLUSIONS: Characteristics of Swiss trauma patients derived from TARN were described for the first time, providing a detailed overview of the institutional trauma population. Based on these results, patient management and hospital resources (e.g. triage of patients, time to CT, staffing during night shifts) could be evaluated as a further step.

Key words: trauma; Switzerland; TARN; registry; epidemiology

Introduction

Trauma is a major global determinant of death, disability and injury. It is estimated that it will become the second most important cause of “life years lost” worldwide within the next 20 years [1, 2]. In western industrialised countries including Switzerland, trauma is the leading cause of death in children and in adults up to 44 years [1–4]. In these patients, severe traumatic brain injury is responsible for the highest mortality and disability rates [5].

During the last two decades, trauma surgeons and emergency physicians have recognised that standardised data collection and statistics could help to improve trauma care in pre-hospital and in-hospital settings and should replace clinical anecdotal evidence. In 1988, Sir Miles Irving from the Royal College of Surgeons of England recommended changes in the management of trauma patients, which included “auditing and researching injury and systems of care” [6]. In the following years, trauma scoring systems were developed. The first reports of the evaluation of trauma systems in 1992 showed “large inter-hospital variations in performance” and “unacceptable delay before treatment” [7]. This initiated a wide debate on the management of trauma victims. In the following years, data was systematically collected in trauma registries such as the English Trauma Audit and Research Network (TARN), the German Trauma Register DGU (TR-DGU) and the US National Trauma Data Bank (NTDB) [1, 8, 9].

In 2008, Bern University Hospital was the first Swiss hospital to join the English trauma registry TARN [6]. A local TARN team was developed and data have been continuously collected and submitted [10].

We now present the first epidemiological trauma registry data from this major Swiss trauma centre. Furthermore, we aimed to identify predictors of mortality.

Patients and methods

Participants

All consecutive trauma patients (≥ 16 years) were analysed who had been admitted to our level I trauma centre in Switzerland between September 1, 2009 and August 31, 2010 and entered into the (TARN) database.

Procedures and outcomes

We present descriptive data from a cohort study of trauma patients treated at our university hospital and entered into TARN, a European multicentre trauma registry. TARN has 189 participating hospitals in England and Wales, one in Denmark, 5 in Ireland and one in Switzerland. TARN includes trauma patients, who a) required hospital admission for ≥ 72 h or b) required admission to the intensive care unit (ICU), or c) who died within 93 days as a result of their injuries. Patients are not included if they were admitted for rehabilitation only, had any brain injury unrelated to trauma, had simple skin lacerations, or had contusions, abrasions or minor penetrating injuries. Moreover, TARN does not include patients older than 65 years with isolated femoral neck or pubic ramus fractures or with single uncomplicated limb injuries [11]. Each injury is coded by the abbreviated injury scale (AIS) [12]. All patient records are anonymised and contain details on the mechanism of injury, age, gender, presenting physiology (at arrival in the emergency department [ED]) and the final outcome (e.g. 30-day mortality) [11].

One TARN data collector at Bern University Hospital screens all trauma cases weekly for inclusion in the database. The data on patient demographics, physiology on admission, diagnostic investigations, and treatment are collected from the clinical notes and are translated into English by a trained emergency physician. The data are then entered into the TARN web-based data collection system. At the TARN headquarters in Manchester (UK), patients and injuries are re-screened by independent and specially trained staff for inclusion criteria and the Injury Severity Score (ISS) is calculated. Outcome is assessed in terms of in-hospital mortality at discharge or within 30 days, whichever occurs first. TARN also calculates a so called "probability of survival" (Ps) for each patient. Ps is an outcome prediction tool using the patients' injuries (ISS), clinical presentation (Glasgow Coma Scale (GCS), Intubation) and personal data (gender, age) to predict the outcome with respect to the average outcome of patients in the database [13].

Statistical analyses

Descriptive data are presented as means, together with the corresponding standard deviations for parametric data or medians, with inter-quartile ranges (IQR) for non-parametric data. Categorical data are reported in numbers and percentages.

The primary outcome of the prospective cohort study was mortality within 30 days.

Age, gender, ISS, Glasgow Coma Scale (GCS), systolic blood pressure (SBP), heart rate (HR), and day and time of admission were considered as potential predictors for death.

Injured body region, time from admission to CT, mechanism of injury, the need for intubation, cardio-pulmonary resuscitation (CPR) and need for a chest drain were secondary exposure variables.

The months of admission were grouped into summer (April to September) and winter seasons (October to March) and days of admission were grouped into weekdays (Monday to Friday) and weekend (Saturday to Sunday). The time of admission was grouped into morning (07:00 to 11:59), afternoon (12:00 to 16:59), evening (17:00 to 21:59) and night (22:00 to 06:59).

AIS ≥ 2 injuries were considered in the analysis and were classified into head, face, chest, abdomen, spine, upper limb, lower limb and external injuries, according to the AIS codes [12].

Missing values were found for the following variables: GCS ($n = 15$, 3.3%), SBP ($n = 5$, 1.1%), heart rate ($n = 8$, 1.7%), time of admission ($n = 33$, 7.2%). As the numbers of missing values were low, analysis was restricted to complete data for any variable.

For each primary exposure variable, the crude odds ratio (OR) was calculated using univariable logistic regression analysis.

In the multivariable logistic regression analysis, age, ISS and GCS were used as continuous variables. The other primary exposure variables were included in the same categories as in the crude analysis. Both uni- and multivariate logistic regression analyses used the Wald test.

Figure 1) Distribution of patients' Injury Severity Scores (ISS) ($n = 458$)

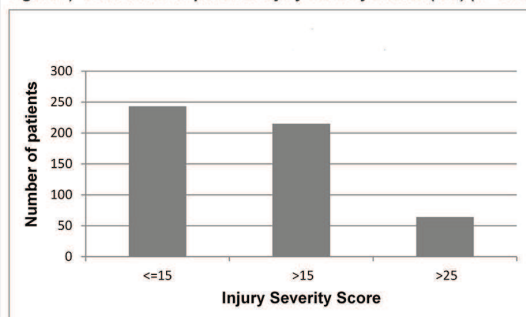


Figure 1

Distribution of Injury Severity Scores ($n = 458$).

Figure 2) Distribution of admissions over the year ($n = 458$)

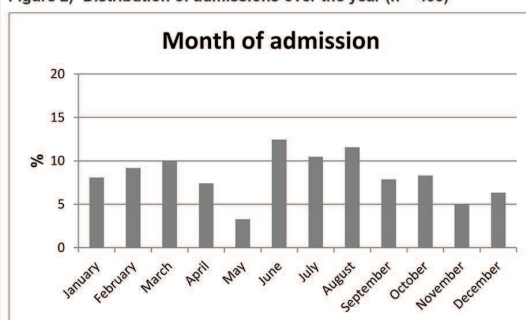


Figure 2

Distribution of admissions over the year ($n = 458$).

The results are reported as ORs with corresponding 95% confidence intervals (CI) and p-values. A p-value <0.05 was used as the level of significance. The stability of the multiple logistic regression models was assessed using the Hosmer and Lemeshow Goodness-of-Fit test. All statistical analyses were conducted using SAS 9.3 (SAS Institute Inc., Cary, NC).

Ethics and funding

Data collection and analysis were performed according to the ethical standards of the hospital. For the use of TARN data, NIGB approval was received for all patients (approval number: PIAG3-04(e)/2006). TARN is funded by contributions from participating hospitals.

Results

Study population

Between September 1, 2009 and August 31, 2010, 458 eligible trauma patients were admitted to our trauma centre and entered in TARN. A total of 71% (n = 325) were male. The median age was 50.5 years (inter-quartile range [IQR] 32.2–67.7), median ISS was 14 (IQR 9–20) and median GCS was 15 (IQR 14–15). A total of 17 patients (3.7%) died within 30 days of trauma (95% CI 2.0%–5.4%).

Descriptive outcome data

As shown in table 1, 215 (47%) patients had an ISS >15, and 64 patients (14%) had an ISS >25 within one year

(fig. 1). All deaths occurred in patients with ISS >15. Most injuries (n = 161, 35%) were due to falls from <2 m, followed by road traffic accidents (n = 133, 29%) and falls >2 m (n = 90, 20%). A total of 52 patients (11%) suffered from sports injuries. Other mechanisms of injury were rare (<5% each).

Injuries (AIS ≥2) were most frequently to the head (39%), followed by injuries to the lower limbs (33%), the spine (28%), the chest (27%), the upper limbs (24%), the face (16%) and the abdomen (11%). External injuries were rare (1%) (table 2). Four patients (0.9%) suffered from hypothermia.

Slightly more patients were admitted from April to September (53%) with a peak between June and August (35%) compared with the winter half of the year. Furthermore, there were slightly more admissions on Saturday and Sunday (14.8%–17.5%), compared to weekdays (Monday to Friday; 11.8%–15.3%); however, these differences were not significant (figs 2 and 3). The time of admission peaked between 12:00 and 22:00 (1–13%), with a second peak between 00:00 and 02:00 (12%) (fig. 4).

A total of 64% (n = 294) of the patients were directly admitted to the trauma centre, whereas 36% (n = 164) were transferred from other hospitals.

A total of 14% (n = 64) of patients were intubated in the pre-hospital setting and 10% (n = 42) were intubated in the in-hospital setting. Furthermore, 12% (n = 55) of patients received a chest drain and 1% (n = 5) needed cardio-pulmonary resuscitation (CPR). Four out of 5 patients that required CPR died.

In 75% (n = 344) of trauma patients, a CT scan was performed with a median time of 0.5 hours (IQR 0.3–0.9) from admission to CT scan. The range of length of stay was 72 hours to 103 days (median 7 days). Patients who died had a median Ps of 56.8% (IQR 40.9%–75.1%). Patients who survived had a median Ps of 97.9% (IQR 93.6%–99.3%).

Multivariable regression analysis

In the multivariable regression analysis, older age, higher ISS, and lower GCS were found to be significant predictors of mortality (table 3). No significant associations with mortality were found for gender, SBP, heart rate, day of the week or time of admission.

Discussion

Within one year, 458 trauma patients, fulfilling the TARN inclusion criteria, were admitted to our level I trauma centre. Of these, 215 patients (47%) suffered injuries with an ISS >15 and 64 patients (14%) with an ISS >25. The mortality was 3.7%, with all deaths occurring in patients with ISS >15. The most frequent type of injury was blunt head trauma. The most common mechanism of injury was a fall <2 m. Older age, increasing ISS, and lower GCS were found to be independently associated with 30-day mortality.

From the data, trauma team activation guidelines can be derived using the predictors of mortality. The time to CT of up to an hour has potential for improvement. In the new Emergency Department which opened in June 2012 the distance to the CT has been shortened. Furthermore, a large

Figure 3) Distribution of admission over the week (n = 458)

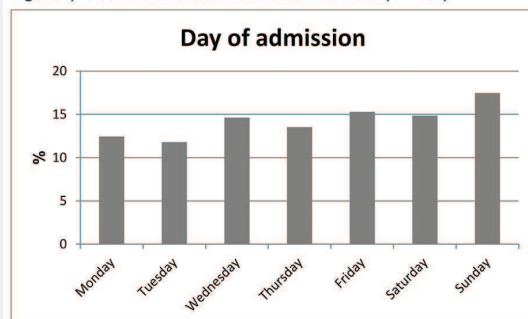


Figure 3

Distribution of admissions over the week (n = 458).

Figure 4) Time of admission (n = 458)

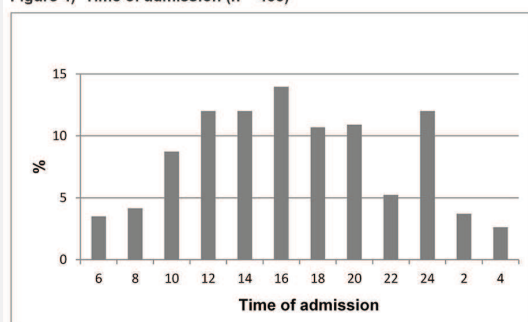


Figure 4

Distribution of admissions over the day (n = 458).

screen showing the patients' vital signs has been implemented in the resuscitation room to make important patient data immediately available for the whole trauma team and specialists in order to simplify communication and speed up diagnostic processes.

Trauma registries are important for clinical documentation, research and quality control. In addition, descriptive epidemiological data are essential in monitoring injury treatment and adverse outcomes. Therefore, the Emergency Department of Bern University Hospital joined the TARN registry in 2008 [10]. The current study summarises the findings from this prospectively entered trauma data base for the first time.

The strengths of TARN are that patients and injuries are re-screened by independent and specially trained staff for inclusion criteria and that the ISS is independently calculated to avoid bias. Moreover, TARN has the unique advantage that it employs a homogeneous database, so that outcomes can be accurately analysed. In addition, inclusion and exclusion criteria are clearly defined [11].

As presented here, the trauma population of Bern University Hospital comprises of patients with a median age of 51 years, a median ISS of 14 and an overall mortality

rate of 3.7%. As expected, blunt injuries were most frequent.

Our findings can help us to identify those patients at higher risk of fatal outcomes [15, 16]. As expected, older age, higher ISS, and lower GCS were found to be significant predictors of mortality [13, 17]. These patients require special attention from the pre- and in-hospital medical teams, as there may be delays in diagnosis and treatment if the patterns of injury are not properly recognised [18]. As a consequence, institutional algorithms may be adjusted to assure early detection of patients at risk of a fatal outcome, with rapid and straightforward provision of life-saving procedures by the appropriate trauma care providers. Cut-off values of basic vital signs to trigger activation of the trauma team have been shown to improve trauma patients' survival. However, these require ongoing critical review to optimise utilisation of hospital resources [19, 20].

The current analysis revealed that the distribution of trauma admissions over the weekdays was fairly constant, but with a moderate increase at the weekends. During the day, the first peak of trauma admissions was observed in the late afternoon and, remarkably, a second peak at midnight (see fig. 4). This important finding should be taken

Table 1: Characteristics of patients at baseline for primary exposure variables.

Exposure variables	No. of patients who died (%)		Crude OR (95% CI)	p-value ¹
	No	Yes		
Age (years)				0.762
16–30	100 (97.1)	3 (2.9)	0.71 (0.15–3.23)	
31–45	94 (95.9)	4 (4.1)	Reference	
46–60	92 (97.9)	2 (2.1)	0.51 (0.09–2.86)	
61–75	93 (95.9)	4 (4.1)	1.01 (0.25–4.16)	
≥75	62 (93.9)	4 (6.1)	1.52 (0.37–6.29)	
Gender				0.564
Female	127 (95.5)	6 (4.5)	1.35 (0.49–3.73)	
Male	314 (96.6)	11 (3.4)	Reference	
GCS				<0.001
3	9 (52.9)	8 (47.1)	81.6 (20.7–321)	
4–5	5 (71.4)	2 (28.6)	36.7 (5.42–249)	
6–8	23 (92.0)	2 (8.0)	7.98 (1.39–45.9)	
9–12	22 (95.7)	1 (4.3)	4.17 (0.45–38.9)	
13–15	367 (98.9)	4 (1.1)	Reference	
ISS				0.053
0–15	243 (100)	0 (0)	<0.01 (<0.01–>999)	
16–25	142 (94.0)	9 (6.0)	0.44 (0.16–1.21)	
>25	56 (87.5)	8 (12.5)	Reference	
SBP (mm Hg)				0.282
<110	59 (92.2)	5 (7.8)	2.91 (0.98–8.68)	
≥110	378 (97.2)	11 (2.8)	Reference	
Heart rate (per minute)				0.001
<60	29 (93.6)	2 (6.4)	3.98 (0.77–20.6)	
60–100	346 (98.3)	6 (1.7)	Reference	
>100	59 (88.1)	8 (11.9)	7.82 (2.62–23.4)	
Season				0.023
Summer	229 (94.2)	14 (5.8)	Reference	
Winter	212 (98.6)	3 (1.4)	0.23 (0.07–0.82)	
Part of the week				0.789
Weekday	299 (96.5)	11 (3.5)	Reference	
Weekend	142 (96.0)	6 (4.1)	1.15 (0.42–3.17)	
Time of the day				0.994
Morning	67 (97.1)	2 (2.9)	0.80 (0.13–4.91)	
Afternoon	140 (96.6)	5 (3.4)	0.95 (0.22–4.09)	
Evening	124 (96.9)	4 (3.1)	0.86 (0.19–3.95)	
Night	80 (96.4)	3 (3.6)	Reference	

CI = confidence interval; GCS = Glasgow Coma Score; ISS = Injury Severity Score; OR = odds ratio; SBP = systolic blood pressure

n = 458, unless fewer as stated due to missing values.

¹ Analysed using the univariate logistic regression (Wald test).

into account when optimising the availability of trauma teams and operating room capacities during the night for example.

TARN is not only a tool for internal analysis, but also a means of benchmarking. Performance of an esteemed level I trauma centre in Switzerland in relation to peer hospitals in Britain would be a topic of interest for further research. As mentioned in the Methods section, TARN calculates a probability of survival (Ps) for each patient which takes into account patients characteristics and injury severity. However, from our experience, the ISS, which is part of Ps, might be misleading to estimate injury severity in patients with severe head and neck injuries or in patients

with multiple severe injuries to the same AIS body region. Therefore, comparison would need to be limited to other neuro-trauma centres in the UK. Furthermore, hospital size and sub-specialities of trauma treated in these hospitals would need to be taken into account (apart from London, trauma care in the UK is often divided between different hospitals).

In the near future, a Swiss Trauma Registry will be established. This important step towards nationwide documentation of trauma patients will improve the characterisation of our trauma population. In addition, it will allow us to critically review the quality of the Swiss trauma system, includ-

Table 2: Secondary exposure variables.

Variable	No. of patients who died (%)		95% CI
	No	Yes	No / Yes
Injured body region¹			
Head	165 (92.2)	14 (7.8)	88.3–96.1 / 3.9–11.8
Lower extremities	146 (96.7)	5 (3.3)	93.8–99.5 / 0.5–6.2
Spine	123 (97.6)	3 (2.4)	95.0–100 / 0.0–0.5
Chest	118 (95.2)	6 (4.8)	91.4–98.4 / 0.1–8.6
Upper extremities	104 (95.4)	5 (4.6)	91.5–99.3 / 0.7–8.5
Face	71 (98.6)	1 (1.4)	95.9–100 / 0.0–4.1
Abdomen	47 (92.2)	4 (7.8)	84.8–99.5 / 0.5–15.2
External injuries	3 (60.0)	2 (40.0)	17.1–100 / 0.0–82.9
Time to CT scan²			
≤30 min.	134 (94.4)	8 (5.6)	91.0–97.8 / 1.9–9.6
31–60 min.	82 (97.6)	2 (2.4)	95.2–100 / 0.0–5.8
>60 min.	57 (100)	0 (0.0)	100–100 / 0.0–0.0
Injury mechanism			
Falls <2 m	158 (98.1)	3 (1.9)	96.0–100 / 0.0–4.0
Road traffic accidents	129 (97.0)	4 (3.0)	94.0–100 / 0.2–5.8
Falls ≥2 m	83 (92.2)	7 (7.9)	86.5–97.8 / 2.0–13.5
Shooting / stabbing	5 (83.3)	1 (16.7)	53.5–100 / 0–46.5
Other	66 (97.1)	2 (2.9)	93.0–100 / 0.0–7.0
Intubation			
No	351 (99.7)	1 (0.3)	99.4–100 / 0.0–0.6
Pre-hospital	53 (82.8)	11 (17.2)	73.4–92.2 / 8.0–26.2
In-hospital	37 (88.1)	5 (11.9)	78.3–97.9 / 2.0–21.8
CPR			
Yes	1 (20.0)	4 (80.0)	0.0–55.1 / 44.9–100
No	440 (97.1)	13 (2.9)	95.6–98.7 / 1.3–4.4
Chest drain			
Yes	53 (96.4)	2 (3.6)	91.4–100 / 0.0–8.6
No	388 (96.3)	15 (3.7)	94.4–98.1 / 1.9–5.6

AIS = Abbreviated Injury Score; CI = confidence interval; CPR = cardiopulmonary resuscitation; CT = computed tomography
n = 458 unless stated otherwise.

¹ Only injuries with an AIS ≥2 are displayed. Total >458 due to multiply injured patients.

² n = 283. 344 patients who received a CT scan; time to CT is available for 283 of these.

Table 3: Multivariable logistic regression analysis to identify predictors for mortality.

Variable	Effect	OR (95% CI)	p-value
GCS	with each additional GCS point	0.71 (0.60–0.85)	<0.001
Age	With each additional year	1.06 (1.01–1.10)	0.010
ISS	With each additional ISS point	1.10 (1.02–1.17)	0.011
Heart rate (per minute)	<60 vs 60–100	4.19 (0.52–34.0)	0.087
	>100 vs 60–100	5.35 (1.10–26.0)	
Gender	Female vs male	2.34 (0.47–11.6)	0.298
SBP (mm Hg)	<110 vs ≥110	1.88 (0.36–9.75)	0.451
Part of the week	Weekend vs weekdays	1.14 (0.21–6.07)	0.880
Time of the day	Morning vs night	0.998 (0.07–14.1)	0.967
	Afternoon vs night	1.5 (0.16–14.1)	
	Evening vs night	1.45 (0.15–14.3)	

CI = confidence interval; GCS = Glasgow Coma Score; ISS = Injury Severity Score; OR = odds ratio; SBP = systolic blood pressure

n = 401

The Hosmer and Lemeshow Goodness-of-Fit test showed p = 0.96, reflecting stable modelling.

ing the possibility of comparing the individual institutional outcomes.

As the sample size was given *a priori*, some associations in the multivariable analysis have wide confidence intervals and may not have resulted in statistically significant findings for this reason. In the multivariable analysis, we have adjusted for the most common confounders. However, some residual confounding may still have occurred. This has been accounted for in the discussion of the results. To minimise selection bias, the study included all patients who were eligible for TARN and patients were prospectively and consecutively collected. As with any measurement of clinical and physiological data, some undifferentiated measurement error may have occurred, resulting in underestimation of associations.

Conclusions

The characteristics of a Swiss trauma population derived from TARN were described for the first time. The prospectively entered trauma registry data with independent re-screening of inclusion criteria and calculation of the Injury Severity Score provide a detailed and accurate overview of the institutional trauma population and their outcomes, thus permitting quality control. Based on these results patient management and hospital resources (e.g. triage of patients, time to CT, staffing during night shifts) could be evaluated as a further step.

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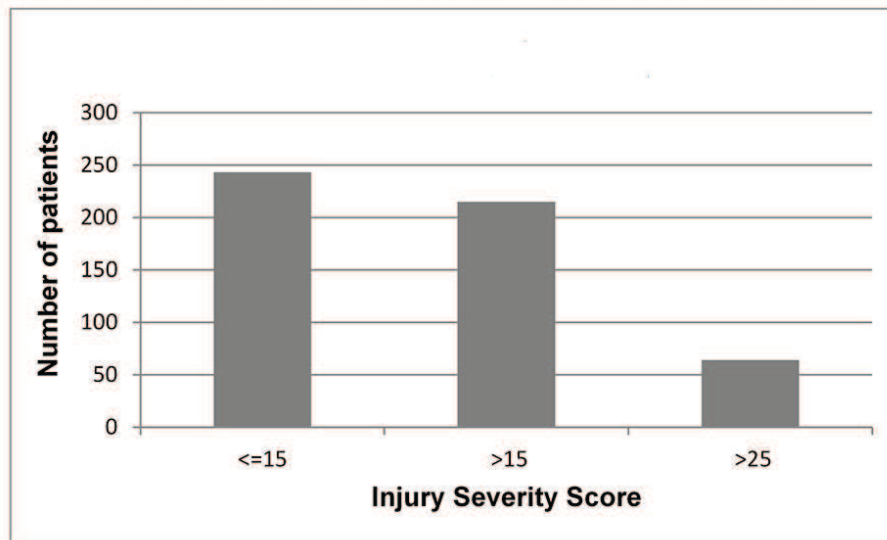
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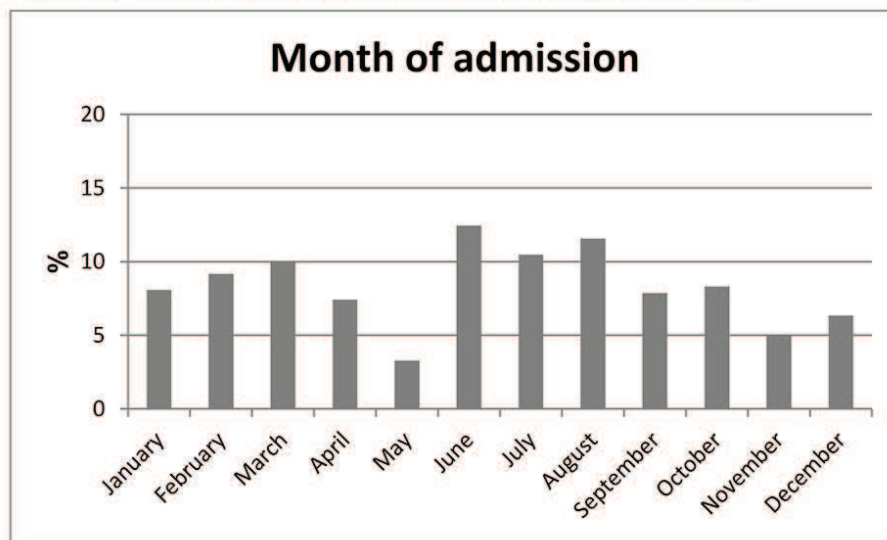
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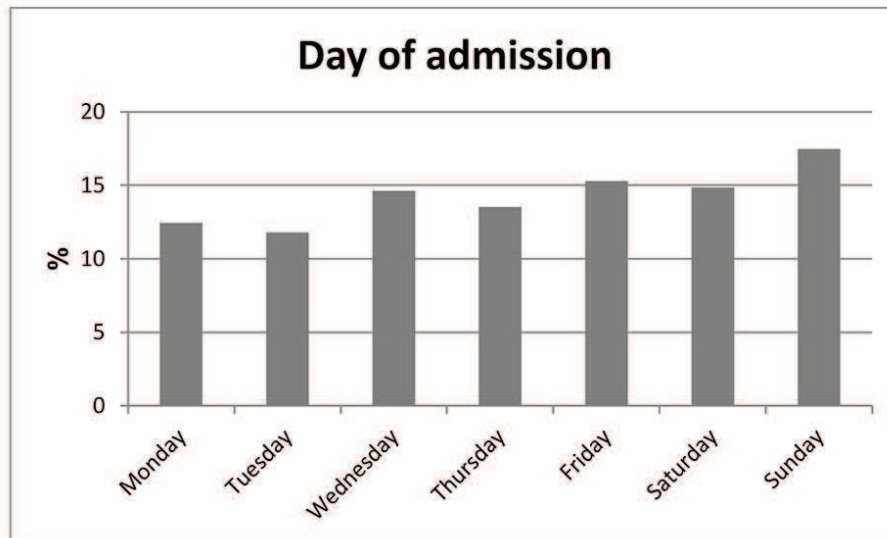
Figures (large format)

Figure 1) Distribution of patients' Injury Severity Scores (ISS) (n = 458)**Figure 1**

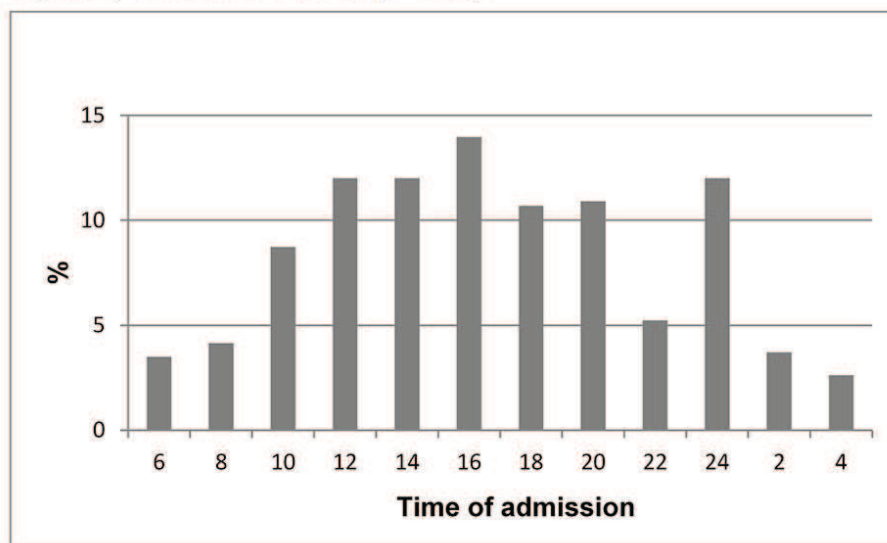
Distribution of Injury Severity Scores (n = 458).

Figure 2) Distribution of admissions over the year (n = 458)**Figure 2**

Distribution of admissions over the year (n = 458).

Figure 3) Distribution of admission over the week (n = 458)**Figure 3**

Distribution of admissions over the week (n = 458).

Figure 4) Time of admission (n = 458)**Figure 4**

Distribution of admissions over the day (n = 458).